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CHEMICAL ABSTRACTS, vol. 104, no. 19, 12th May 1986, page 333, abstract no. 164815m, Columbus, Ohio, US;

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CHEMICAL ABSTRACTS, vol. 102, no. 5, 4th February 1985, page 370, abstract no. 43529w, Columbus, Ohio, US; V. PENEVA et al.: "Investigation of the influence of erythrocyte concentration and of the protective medium on the polarization phenomena in lyophilized erythrocytes".

CRYOBIOLOGY, vol 8, no. 4, 1971, page 384; A.P. MacKENZIE et al.: "Freeze-drying preservation of human erythrocytes"

PATENT ABSTRACTS OF JAPAN, vol. 6, no. 68 (C-100)[946], 30th April 1982; & JP-A-57 7419 (TOUSHIBA KAGAKU KOGYO K.K.) 14-01-1982

Description

This invention relates to the general field of biochemistry and medical sciences, and specifically to processes for the preservation and storage of cells, particularly red blood cells.

Laboratory cell preservation and storage have been significant problems for a variety of plant and animal cells. Freezing the cells in an aqueous solution and thawing the cells prior to use is not uncommon, but the viability of the cells after this process is generally severely affected and chromosome abnormalities often result from this freeze-thaw process. In addition, the expense of keeping the cells frozen is significant. US-A-3344167 relays to the low temperature preservation of biological substances including the freezing and thawing of red blood cells.

For example, there has been a need for improved methods for the storage of blood and blood constituents. Blood is a major tissue of the human body, and has as a predominant role the delivery of oxygen from the lungs to peripheral tissues. This role is carried out by erythrocytes, i.e., red blood cells (RBC). The oxygen is furnished from the lungs by an exchange-diffusion system brought about by a red, iron-containing protein called hemoglobin. When hemoglobin combines with oxygen, oxyhemoglobin is formed and after oxygen is given up to the tissues, the oxyhemoglobin is reduced to deoxyhemoglobin.

The red cell membrane is composed of two major structural units, the membrane bilayer and a cytoskeleton. A lipid bilayer and integral membrane proteins form the membrane bilayer, which has little structural strength and fragments readily by vesiculation. The other major component, the membrane skeleton, stabilizes the membrane bilayer and provides resistance to deformation. The cytoskeleton is linked to the bilayer in the erythrocyte membrane, possibly by lipid-protein as well as protein-protein associations. The hemoglobin, and other RBC components, are contained within the red cell membrane.

In adults, bone marrow is active in the formation of new red blood cells. Once erythrocytes enter the blood, these cells have an average lifetime of about 120 days. In an average person, about 0.83% of the erythrocytes are destroyed each day by phagocytosis, hemolysis or mechanical damage in the body, and the depleted cells are renewed from the bone marrow.

A wide variety of injuries and medical procedures require the transfusion of whole blood or a variety of blood components. Every patient does not require whole blood and, in fact, the presence of all of the blood components can cause medical problems. Separate blood fractions can be stored under those special conditions best suited to assure their biological activity at the time of transfusion. For example, when donor blood is received at a processing center, erythrocytes are separated and stored by various methods. Such cells are storable in citrate-phosphate-dextrose at 4 °C for up to five weeks, generally as a unit of packed erythrocytes having a volume of from 200 to 300 ml and a hematocrit value (expressed as corpuscular volume percent) of 70 to 90. Erythrocytes may also be treated with glycerol and then frozen at from -30 ° to -196 °C and stored for up to seven years in a glycerol solution, but must be kept frozen at low temperatures in order to survive sufficiently for transfusion. Both these methods require careful maintenance of storage temperature to avoid disruption of the desired biological activity of the erythrocytes, and provide a twenty-four hour survival time for at least 70% of the transfused cells, which is considered to be an acceptable level for use in transfusion practice in accordance with the American Association of Blood Bank standards.

It has thus been a desideratum to obtain a method for the storage of cells, and in particular red blood cells, which is not dependent on the maintenance of specific storage temperatures or other storage conditions. Such a method would facilitate the availability of erythrocytes for medical purposes and assist in the storage and shipment of various mammalian cells and plant cells, particularly protoplasts, for research and hybrid development.

One such desired method has been the lyophilization (freeze-drying) of cells, since such cells could be stored at room temperature for an extended period of time and easily reconstituted for use. Freeze-dried red blood cells could thus be easily stored for use in transfusions. However, prior to our invention, it has been impossible to freeze-dry erythrocytes in a manner which permits the reconstitution of the cells to form erythrocytes with an intact cytoskeleton and biologically-active hemoglobin, i.e., viable red blood cells. When RBCs have been lyophilized according to previous methods, for example in either an aqueous or phosphate-buffered saline (PBS) solution, the reconstituted cells are damaged to the extent that the cells are not capable of metabolizing, and the cell hemoglobin cannot carry oxygen. Glutaraldehyde-fixed erythrocytes, which have been lyophilized and reconstituted, have found use primarily in agglutination assays. EP-A-0356258 (same date of filing ; priority dates 26.08.88 and 30.06.89) discloses a process and media for the lyophilization of red blood cells.

The process of the present invention is defined in claim 1 and allows for the lyophilization of cells under conditions which are not deleterious to the structure and the biological activity of the cell, and which permits the reconstitution of the lyophilized cells to form cells which are identical to the natural cells in a biological

or botanical activity. Briefly, the process comprises immersing a plurality of cells in an essentially isotonic aqueous solution containing a monosaccharide and which preferably includes an amphipathic polymer, freezing the solution, and drying the solution to yield freeze-dried cells which, when reconstituted, produce a significant percentage of intact and viable cells.

While the invention is applicable to a wide variety of plant and animal cells, the process of the invention is preferably applied to red blood cells and allows for the lyophilization of erythrocytes under conditions which maintain structure of the cell and the biological activity of the hemoglobin, and which permits the reconstitution of the lyophilized red blood cells to allow use on a therapeutic level. The carbohydrate of the lyophilization and reconstitution media is biologically compatible with the cells, that is, non-disruptive to the cells, and is preferably one which permeates, or is capable of permeating the membrane of the cells. The carbohydrate of the lyophilization media is a monosaccharide, since disaccharides do not appear to permeate the membrane to any significant extent. Monosaccharide pentoses and hexoses are preferred in concentrations of from 7.0 to 37.5%, preferably about 23%. Xylose, glucose, ribose, mannose and fructose are employed to particular advantage. The lyophilization of RBCs in such a monosaccharide solution improves the recovery after lyophilization to at least 50% intact cells, as opposed to the fusing and destruction of the cell membrane during lyophilization in water solutions without the monosaccharide Such reconstituted cells are only useful in producing ghost cells for agglutination assays or biochemical research, i.e., as model membrane systems. They are not viable cells capable of transporting oxygen or metabolizing.

As stated above, the addition to the carbohydrate solution of a water soluble, biologically compatible polymer adds significantly to the percentage of biologically-active hemoglobin which is retained in the cells and recovered after reconstitution of red blood cells after lyophilization. The polymer will preferably be amphipathic, meaning that there are hydrophilic and hydrophobic portions on a single molecule of the polymer. The polymer may be present in the solution in concentrations of from 0.7% up to saturation. Preferably, the polymer has a molecular weight in the range of from about 1K to about 360K, most preferably from about 5K to 80K, and most preferably to 50K, and is present in a concentration of from about 3.5% up to the limit of solubility of the polymer in the solution. Polymers selected from the group consisting of polyvinylpyrrolidone (PVP) and polyvinylpyrrolidone derivatives, and dextran and dextran derivatives provide significant advantages. Amino acid based polymers (i.e., proteins) or hydroxyethyl starch may also be employed. Other amphipathic polymers may be used, such as poloxamers in any of their various forms. The use of the monosaccharide polymer solution in the lyophilization of red blood cells allows for the recovery of intact cells, a significant percentage of which contain biologically-active hemoglobin. While not intending to be bound by any theory, the amphipathic properties of the polymer allow them to bind to the cell membrane while protecting the membrane surface by extension of the hydrophilic portion into the aqueous environment. This may alleviate the damage to the cell membrane which causes other problems, such as cell aggregation. The use of the monosaccharide polymer solution in the lyophilization of red blood cells allows for the recovery of intact cells, a significant percentage of which contain biologically-active hemoglobin.

Thus, cells lyophilized according to the present invention are preferably reconstituted by contacting the cells with an aqueous solution containing a carbohydrate in a concentration of at least 0.7% by weight and/or a polymer having a molecular weight of from 1K to 360k in a concentration of up to 20% by weight. Preferably the concentration is from 0.7% to 30% by weight and the reconstituting solution is at a temperature of from 20 °C to 40 °C.

As is shown by the data set forth below, the described solutions provide media which permit cells, particularly red blood cells, to be subjected to the stresses of freezing, water sublimation and reconstitution and to form freeze-dried cells which may be reconstituted to yield cells which are capable of functioning normally.

Unless indicated otherwise by the terminology or the context, all percentages set forth herein are expressed as weight percentages (i.e., weight of the solute versus the total weight of the solution).

As noted above, the process of the invention includes a medium for the lyophilization of erythrocytes which when reconstituted are intact and biologically-active. While the media of the invention are novel it will be understood that apparatus and related techniques are known by those of skill in the art for the lyophilization of various materials, and biological samples in particular, and only the specific temperatures and apparatus employed in the examples are described herein. From this description, one of ordinary skill in the art will be capable of employing the media of the invention in a process for the freeze-drying of red blood cells which after reconstitution are intact and viable.

The term lyophilization is broadly defined as freezing a substance and then reducing the concentration of one of the solutes, namely water, by sublimation and desorption, to levels which will no longer support biological or chemical reactions. Usually, the drying step is accomplished in a high vacuum. However, with

respect to the storage of cells and particularly erythrocytes, the extent of drying (the amount of residual moisture) is of critical importance in the ability of cells to withstand long-term storage at room temperature. In the method of the invention, cells may be lyophilized to a residual water content of less than 10%, preferably less than 5%, and most preferably to a water content of less than 3%.

EXAMPLE ONE

Packed red blood cells of variable blood type were obtained from a hospital blood donor center or drawn from healthy volunteers using heparin as an anticoagulant.

Repeated samples of these blood cells were washed with a phosphate buffered saline solution (10 mM mono- and di-basic sodium phosphate, 150 mM sodium chloride, 5 mM dextrose, and 10 mM adenosine at pH 7.2) three times with centrifugation at 14,000 rpm for 6 to 10 seconds to separate plasma and/or other cell types from the red blood cells.

Samples of these packed red blood cells were then suspended in a lyophilizing buffer containing 26.5% glucose in PBS solution at pH 7.2.

The suspension was then transferred to a flask which was subsequently immersed in liquid nitrogen (-196 °C) until the sample was frozen. The flask was rotated evenly in the liquid nitrogen to assure even dispersion of solution on the walls of the flask.

The frozen samples were transferred to a bench top lyophilizer (Labconco model 4.5) operating at less than 100 microns of mercury vacuum with an inner chamber temperature of -56 °C. Samples were allowed to dry thoroughly (6-24 hours) until crystalline in appearance and brittle to touch and the flask was allowed to return to room temperature.

The samples were rehydrated at 37 °C using a solution containing 25.5% sucrose in a phosphate buffered saline solution. A volume of the rehydrating solution was added equivalent to the initial volume of the sample prior to drying.

It was found upon examination of the cells with an optical microscope that about 50% of the red blood cells had intact cell membranes. However, the hemoglobin was found not to be cell associated. Nonetheless, the hemoglobin in the solution was functional and if present in the cells would be effective as an oxygen carrier. Repeating this procedure with fructose and ribose solutions having concentrations of from about 7.0 to 37.5% produced nearly equal results, as did buffered solutions of xylose and mannose at concentrations of from about 7.0 to 37.5%.

Specifically, various monosaccharides were employed in the lyophilization of RBCs as described in this example, and the distribution of the hemoglobin in the recovered solution was noted. oxyhemoglobin is capable of transporting oxygen to mammalian tissue. Methemoglobin is hemoglobin which cannot bind oxygen, but can possibly be reversed to form oxyhemoglobin when found in lower concentrations by the enzyme NADH methemoglobin reductase. Hemochrome is irreversibly degraded hemoglobin. In Table I, the recovery of greater than 90% oxyhemoglobin from cells lyophilized with solutions of ribose, mannose, fructose, xylose and glucose is shown.

TABLE I

%Carbohydrate	%OxyHb	%MetHb	%Hemochrome
23.1 Ribose	93.1	5.4	1.5
26.5 Mannose	94.2	6.0	0
26.5 Fructose	98.0	1.3	0.7
26.5 Sorbose	56.9	40.9	2.3
15.2 Galactose	81.0	17.3	1.7
23.1 Xylose	96.7	3.6	0
26.5 Glucose	98.1	1.8	0.1

EXAMPLE TWO

A number of samples of packed red blood cells, obtained and washed as described in Example One, were suspended in a lyophilizing buffer containing 23.1% glucose and a concentration of either (a) 18% of 10K or (b) 12.8% of 40K polyvinylpyrrolidone in PBS at pH 7.2.

The suspension was then transferred to a flask which was subsequently immersed in liquid nitrogen (-196 • C) until the sample was frozen. The flask was rotated evenly in the liquid nitrogen to assure even dispersion of solution on the walls of the flask.

The frozen sample was transferred to a bench top lyophilizer (Labconco model 4.5) operating at less than 100 microns of mercury vacuum with an inner chamber temperature of -56 • C. Samples were allowed to dry thoroughly (6-24 hours) until crystalline in appearance and brittle to touch and the flask was allowed to return to room temperature.

The samples were rehydrated at 37 • C using a solution containing 25.5% sucrose in a phosphate buffered saline solution. A volume of the rehydrating solution was added equivalent to the initial volume of the sample prior to drying.

The samples were centrifuged at 14,000 rpm in an Eppendorf microcentrifuge to pellet the rehydrated red blood cells in suspension.

The results of incorporating the polymer with the above described carbohydrate in the buffered lyophilizing solution produced surprising results not only in that the recovery of intact cells was maintained at 52.9 ± 7.9%, but in addition the solution allowed hemoglobin retention by the cells of from 27.4 up to 42.2% for the 10K PVP and from 57.3 up to 65.5% for the 40K PVP, with greater than 80% of the hemoglobin being oxyhemoglobin. Further testing has shown that 24K PVP at a concentration of 12.8% and a glucose concentration of 23.1% produces even better results both in cell and hemoglobin recovery.

EXAMPLE THREE

The procedure described in Example Two was repeated, with different carbohydrates substituted for glucose in the lyophilizing buffer. Two different molecular weights of polyvinylpyrrolidone were used. The results are shown in Table II.

TABLE II

PVP MW	%Carbohydrate	%Cell Recovery	%Hb Recovery
10K*	12.2 Galactose	27.7	10.3
	21.7 Mannose	57.6	30.6
	18.8 Xylose	63.9	32.3
	21.7 Fructose	54.6	28.1
	21.7 Glucose	59.0	28.6
24K**	13.0 Galactose	26.3	13.8
	23.1 Mannose	51.8	57.2
	20.0 Xylose	48.4	55.9
	23.1 Fructose	48.8	59.3
	23.1 Glucose	59.0	52.7

*with a PVP concentration of from 18.1 to 20.3%.
**with a PVP concentration of from 12.8 to 14.5%.

Trehalose and sucrose in the lyophilizing solution showed marginal cell recovery, but no hemoglobin recovery.

EXAMPLE FOUR

The procedure described in Example Two (using from 21.7 to 26.3% glucose as the carbohydrate) was repeated substituting polyvinylpyrrolidone of different molecular weights and concentrations for those used in the lyophilizing buffer of the previously described Example. All other conditions were repeated as described in Example Two. the results are shown in Table III. The column headed MCHC refers to the mean cell hemoglobin content of the reconstituted cells. The MCHC of normal RBCs is 34 ± 2. Table III demonstrates that PVP may be employed with molecular weights of from 10 to 40K in concentrations of from 0.7 to 18.1%. The 40KT PVP had a viscosity of about 26 to 35 poise, and the 40K PVP had a viscosity of about 28 to 32 poise. Maltose showed no cell or hemoglobin recovery.

TABLE III

PVP MW	Conc. (%)	%Hb Recovery	MCHC
10K	3.5	13.6	-
	6.8	15.0	34.9
	12.8	30.1 ± 4.1 (n = 3)	20.9 ± 3.1 (n = 3)
	18.1	36.5	28.1
24K	3.5	24.7	17.3
	6.8	52.9	20.9
	12.8	52.7 ± 6.3 (n = 4)	27.4 ± 4.3 (n = 4)
	18.1	52.2 ± 6.9 (n = 2)	-
40K	3.5	17.7	-
	6.8	31.0	22.5
	12.8	61.4 ± 4.1 (n = 3)	25.7 ± 9.2 (n = 3)
	18.1	52.0 ± 1.7 (n = 2)	37.4
40KT	3.5	17.7	-
	6.8	31.8	25.0
	12.8	56.8 ± 0.4 (n = 2)	36.3 ± 2.8 (n = 2)
	18.1	50.0	29.4
360K	0.7	9.4	-
	8.5	12.2	-

EXAMPLE FIVE

The experiment described in Example Two was repeated using polymers other than polyvinylpyrrolidone in the lyophilizing buffer. The results are summarized in Table IV.

TABLE IV

Polymer	MW	%Conc.	%Hb Recovery
Dextran	10K	3.5	26.1
		6.8	29.8
		12.8	26.5
		18.1	30.2
	40K	3.5	24.7
		6.8	19.5
		12.8	25.9
		18.1	16.6
	80K	3.5	15.2
		6.8	26.5
		12.8	20.2
		18.1	18.7
Ficoll	70K	3.5	17.3
		6.8	19.1
	400K	0.7	17.2
		3.5	17.9
Fish Gelatin		1.4	19.0
		6.8	18.4
Dextrin		1.4	20.4
		6.8	13.1
Albumin		1.4	29.7

EXAMPLE SIX

Samples of packed red blood cells were obtained and washed as described in Example One. These cells were suspended in a lyophilizing buffer of 12.8% 24K PVP and 23.1% glucose in phosphate buffered saline. The samples were lyophilized and reconstituted as described in Example Two, but with the various solutions used in the reconstitution of the cells. When water was the sole reconstituting liquid, the cells lysed within thirty minutes after reconstitution. An isotonic reconstituting solution, such as PBAS or PBSGA (PBS with the addition of 5 mmol glucose and 10 mmol adenosine) showed improvement, as did the use of reverse PBS, which employs potassium rather than sodium salts. Significant improvements were shown by the use of concentrations of up to 12.8% of either 10K or 24K PVP in the reconstitution solution.

The use of a carbohydrate in a minimum concentration of at least 0.7 to 3.6%, and most preferably at least 3.6%, provides better cell morphology after reconstitution Both mono- and disaccharides may be employed for this purpose, although glucose, mannose, trehalose and sucrose are preferred with sucrose being the most preferred carbohydrate. These data are shown in Table V, wherein all carbohydrate and polymer solutions are formed in PBS.

TABLE V

Solution		% Cell Recovery	% Hb Recovery	MCHC
Water		49.3 ± 3.0	37.4 ± 1.1	29.9 ± 1.8
PBS		59.2	34.4	24.8
PBSGA		60.6	42.4	31.2
Reverse PBS		52.6	51.3	25.8
Glucose 15.9%		52.5	57.3	32.9
Mannose 15.9%		55.5	60.7	28.0
Trehalose 27.4%		65.7	59.4	24.9
Sucrose	1.7%	61.7	45.6	24.4
	3.3%	43.8	46.2	27.3
	7.9%	49.5	52.8	24.6
	25.5%	49.6 ± 10.6	51.4 ± 5.1	25.5 ± 2.1
4.8 % 10K PVP		55.6 ± 11	52.3 ± 3.0	23.5 ± 1.4
16.7% 10K PVP		60.8	67.7	28.4
4.8% 24K PVP		52.2	38.3	26.0
16.7% 24K PVP		53.8 ± 9.4	73.1 ± 8.1	28.2 ± 8.7
3.6% 10K PVP + 24.6% Sucrose		65.0 ± 6.5	59.0 ± 7.6	28.2 ± 8.7
13.0% 10K PYP + 22.2% Sucrose		39.5	61.6	27.8
3.6% 24K PVP + 24.6% Sucrose		64.8	59.3 ± 6.9	26.5
13.0% 24K PVP + 22.2% Sucrose		77.7	76.4 ± 4.2	31.5

Claims

1. A process for the lyophilization of cells having a cell membrane, comprising immersing a plurality of cells in a water solution which includes a monosaccharide, which is capable of permeating the membrane of the cells, in a concentration of from 7.0 to 37.5%; freezing the solution; and drying the frozen cells by sublimation of the water.

2. A process for the lyophilization of cells, as claimed in claim 1 wherein the water solution further includes a polymer having a molecular weight of from about 1K to about 360K which is present in a concentration of from about 0.7% up to saturation in the solution.

3. A process as claimed in claim 1 or claim 2 wherein the monosaccharide is selected from pentoses or hexoses.

4. A process as claimed in any one of claims 1 to 3 wherein the monosaccharide is selected from xylose, glucose, ribose, mannose or fructose.

5. A process as claimed in any one of claims 1 to 4, wherein the monosaccharide is present in the solution in a concentration of about 23%.

6. A process as claimed in any one of claims 2 to 5 wherein said polymer is amphipathic.

7. A process as claimed in any one of claims 2 to 6 wherein said polymer has a molecular weight in the range of about 5K to about 80K.

8. A process as claimed in any one of claims 2 to 7 wherein the polymer is selected from polyvinylpyrrolidone or dextran.

9. A process as claimed in any one of claims 1 to 8 wherein the cells are red blood cells.

10. A medium for the lyophilization of cells, comprising a buffered solution which includes:
a monosaccharide which is present in the solution in a concentration of from about 7.0 to 37.5%, and
a polymer having a molecular weight of from about 1K to about 360K which is present in a concentration of from about 0.7%.

11. A medium as claimed in claim 10 wherein the monosaccharide is selected from pentoses or hexoses.

12. A medium as claimed in claim 10 or clai, 11 wherein the monosaccharide is selected from xylose, glucose, ribose, mannose or fructose.

13. A medium as claimed in any one of claims 10 to 12 wherein the monosaccharide is present in the solution in a concentration of about 23%.

14. A medium as claimed in any one of claims 10 to 13 wherein the polymer is amphipathic.

15. A medium as claimed in any one of claims 10 to 14 wherein the polymer has a molecular weight in the range of about 5K to about 80K.

16. A medium as claimed in any one of claims 10 to 15 wherein the polymer is selected from polyvinylpyrrolidone or dextran.

17. A medium for the lyophilization of cells as claimed in any one of claims 10 to 16 wherein the cells are red blood cells.

Patentansprüche

1. Verfahren zur Lyophilisierung von eine Zellmembran aufweisenden Zellen, das folgende Stufen umfaßt: Eintauchen einer Vielzahl von Zellen in eine wässerige Lösung, die ein Monosaccharid enthält, das die Zellmembran zu durchdringen vermag, in einer Konzentration von 7,0 bis 37,5%, Einfrieren der Lösung und Trocknung der gefrorenen Zellen durch Sublimierung des Wassers.

2. Verfahren zur Lyophilisierung von Zellen nach Anspruch 1, bei dem die wässerige Lösung außerdem noch ein Polymer mit einem Molekulargewicht von ca. 1 K bis ca. 360 K enthält, das in einer Konzentration von ca. 0,7 % bis zur Sättigung in der Lösung vorliegt.

3. Verfahren nach einem der Ansprüche 1 oder 2, bei dem das Monosaccharid ausgewählt wird unter Pentosen und Hexosen.

4. Verfahren nach einem der Ansprüche 1 bis 3, bei dem das Monosaccharid ausgewählt wird unter Xylose, Glucose, Ribose, Mannose oder Fruktose.

5. Verfahren nach einem dar Ansprüche 1 bis 4, bei dem das Monosaccharid in dar Lösung in einor Konzentration von ca. 23% vorliegt.

6. Verfahren nach einem der Ansprüche 2 bis 5, bei dem das Polymer amphipathisch ist.

7. Verfahren nach einem der Ansprüche 2 bis 6, bei dem das Polymer ein Molekulargewicht im Bereich von ca. 5 K bis ca. 80 K hat.

8. Verfahren nach einem der Ansprüche 2 bis 7, bei dem das Polymer ausgewählt wird unter Polyvinylpyrrolidon oder Dextran.

9. Verfahren nach einem der Ansprüche 1 bis 8, bei dem die Zellen Erythrozyten sind.

10. Medium zur Lyophilisierung von Zellen, das eine gepufferte Lösung darstellt, die folgende Komponenten umfaßt:
ein Monosaccharid, das in der Lösung in einer Konzentration von ca. 7,0 bis 37,5% vorliegt und
ein Polymer mit einem Molekulargewicht von ca. 1 K bis ca. 360 K in einer Konzentration von 0,7%.

11. Medium nach Anspruch 10, bei dem das Monosaccharid ausgewählt wird unter Pentosen oder Hexosen.

12. Medium nach Anspruch 10 oder 11, bei dem das Monosaccharid ausgewählt wird unter Xylose, Glucose, Ribose, Mannose oder Fructose.

13. Medium nach einem der Ansprüche 10 bis 12, bei dem das Monosaccharid in dar Lösung in einer Konzentration von ca. 23% vorliegt.

14. Medium nach einem der Ansprüche 10 bis 13, bei dem das Polymer amphipatisch ist.

15. Medium nach einem der Ansprüche 10 bis 14, bei dem das Polymer ein Molekulargewicht im Bereich von ca. 5 K bis ca. 80 K hat.

16. Medium nach einem der Ansprüche 10 bis 15, bei dem das Polymer ausgewählt wird unter Polyvinylpyrrolidon oder Dextran.

17. Medium zur Lyophilisierung von Zellen nach einem der Ansprüche 10 bis 16, bei dem die Zellen Erythrozyten sind.

Revendications

1. Procédé de lyophilisation de cellules possédant une membrane cellulaire, caractérisé en ce que l'on plonge une multiplicité de cellules dans une solution aqueuse qui comprend un monosaccharide, qui est capable de traverser la membrane des cellules, en une concentration de 7,0 à 37,5%, on congèle la solution et on sèche les cellules congelées par sublimation de l'eau.

2. Procédé de lyophilisation de cellules suivant la revendication 1, caractérisé en ce que la solution aqueuse comprend en outre un polymère possédant un poids moléculaire qui varie d'environ 1K à environ 360K, qui est présent en une concentration allant d'environ 0,7% jusqu'à la saturation dans la solution.

3. Procédé suivant la revendication 1 ou la revendication 2, caractérisé en ce que le monosaccharide est choisi parmi les pentoses et les hexoses.

4. Procédé suivant l'une quelconque des revendications 1 à 3, caractérisé en ce que le monosaccharide est choisi parmi le xylose, le glucose, le ribose, le mannose et le fructose.

5. Procédé suivant l'une quelconque des revendications 1 à 4, caractérisé en ce que le monosaccharide est présent dans la solution en une concentration d'environ 23%.

6. Procédé suivant l'une quelconque des revendications 2 à 5, caractérisé en ce que le polymère précité est amphipathique.

7. Procédé suivant l'une quelconque des revendications 2 à 6, caractérisé en ce que le polymère précité possède un poids moléculaire qui varie dans la plage d'environ 5K à environ 80K.

8. Procédé suivant l'une quelconque des revendications 2 à 7, caractérisé en ce que le polymère est choisi parmi la polyvinylpyrrolidone et le dextrane.

9. Procédé suivant l'une quelconque des revendications 1 à 8, caractérisé en ce que les cellules sont des cellules sanguines rouges du sang ou hématies.

10. Milieu de lyophilisation de cellules, caractérisé en ce qu'il est constitué par une solution tamponnée qui comprend :

un monosaccharide qui est présent dans la solution en une concentration qui fluctue d'environ 7,0 à 37,5% et

un polymère possédant un poids moléculaire qui varie d'environ 1K à environ 360K, qui est présent en une concentration d'environ 0,7%.

11. Milieu suivant la revendication 10, caractérisé en ce que le monosaccharide est choisi parmi les pentoses et les hexoses.

12. Milieu suivant la revendication 10 ou la revendication 11, caractérisé en ce que le monosaccharide est choisi parmi le xylose, le glucose, le ribose, le mannose et le fructose.

13. Milieu suivant l'une quelconque des revendications 10 à 12, caractérisé en ce que le monosaccharide est présent dans la solution en une concentration d'environ 23%.

14. Milieu suivant l'une quelconque des revendications 10 à 13, caractérisé en ce que le polymère est amphipathique.

15. Milieu suivant l'une quelconque des revendications 10 à 14, caractérisé en ce que le polymère possède un poids moléculaire qui varie dans la plage d'environ 5K à environ 80K.

16. Milieu suivant l'une quelconque des revendications 10 à 15, caractérisé en ce que le polymère est choisi parmi la polyvinylpyrrolidone et le dextrane.

17. Milieu pour la lyophilisation de cellules suivant l'une quelconque des revendications 10 à 16, caractérisé en ce que les cellules sont des globules rouges du sang ou hématies.